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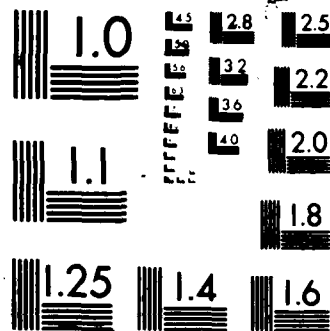
EQUIPMENT FOR TURBULENT HEAT TRANSFER TEST APPARATUS
(U) MISSISSIPPI STATE UNIV MISSISSIPPI STATE DEPT OF
MECHANICAL AND NUCLEAR ENGINEERING H W COLEMAN AUG 86
AFOSR-TR-87-0555 AFOSR-85-0075 F/G 14/2

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INSTRUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED		1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION/AVAILABILITY OF REPORT APPROVED FOR PUBLIC RELEASE DISTRIBUTION IS UNLIMITED	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE		5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TB- 87-0555	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)		6a. NAME OF MONITORING ORGANIZATION AFOSR/NA	
6a. NAME OF PERFORMING ORGANIZATION MISSISSIPPI ST UNIV	6b. OFFICE SYMBOL (If applicable) NA	7a. ADDRESS (City, State and ZIP Code) BUILDING 410 BOLLING AFB, DC 20332-6448	
8a. NAME OF FUNDING/SPONSORING ORGANIZATION AFOSR/NA		9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-85-0075	
8b. ADDRESS (City, State and ZIP Code) BUILDING 410 - BOLLING AFB, DC 20332-6448		10. SOURCE OF FUNDING NOS	
11. TITLE (Include Security Classification) (U) EQUIPMENT FOR TURBULENT HEAT TRANSFER TEST APPARATUS		PROGRAM ELEMENT NO 61102F	TASK NO. A1
12. PERSONAL AUTHOR(S) H W COLEMAN		PROJECT NO. 2307 2717	WORK UNIT NO.
13a. TYPE OF REPORT FINAL	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Yr. Mo. Day) AUG 1986	15. PAGE COUNT 8
16. SUPPLEMENTARY NOTATION			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB GR	
		EQUIPMENT, INSTRUMENTATION, HEAT TRANSFER LAB	
19. ABSTRACT (Continue on reverse if necessary and identify by block number) EQUIPMENT FOR A HEAT TRANSFER WIND TUNNEL TEST FACILITY WAS PURCHASED UNDER THE UNIVERSITY RESEARCH INSTRUMENTATION PROGRAM (URIP).			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS <input type="checkbox"/>		21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL HENRY E HELIN, CAPTAIN, USAF		22b. TELEPHONE NUMBER (Include Area Code) 202-767-4935	22c. OFFICE SYMBOL AFOSR/NA

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AFOSR-TB- 87-0555

Final Report

on

Grant No. AFOSR-85-0075

A University Research Instrumentation Program
Grant for Acquiring Equipment and Constructing
a Turbulent Heat Transfer Test Apparatus (Wind
Tunnel) and a Water Tunnel

Approved for public release;
distribution unlimited.

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August 1986

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MATTHEW J. KERPER
Chief, Technical Information Division

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I. Introduction

This grant was for acquiring the equipment for and constructing a wind tunnel facility called the Turbulent Heat Transfer Test Apparatus (THTTA). The THTTA was designed specifically for providing quality heat transfer and fluid dynamics data for turbulent flow over rough surfaces. In April 1985, Amendment A to the original grant added funds to acquire the equipment for and construct a companion water tunnel facility which would use the same data acquisition and control system as the THTTA.

Both facilities have been constructed and research in the facilities is proceeding with funding from other contracts and grants.

In Section II, a listing of the major pieces of equipment (along with manufacturer and cost) is presented. In Section III, the circumstances and reasons for changes from the equipment list in the original proposal are discussed. In Section IV, a brief summary of the research being conducted using the THTTA and the water tunnel is given.

II. Equipment Acquired

The equipment is listed within the general categories identified in the Grant as follows:

A. Air Flow System

Blower (Buffalo Forge Model 45 AW without motor)	\$ 1,967.00
Motor/Eddy Current Clutch Units with Clutch Controllers (Eaton Model AS-280-11 25 hp unit for use with blower and Eaton Model ED-251504-1 15 hp unit for use with pump in water tunnel)	10,332.00

Honeycomb (Hexcel Corp.)	302.15
Stainless Steel Screens (Western Wire)	311.30
B. Water Flow System	
Heat Exchanger (Trane Co.)	\$ 1,398.00
Motor-driven Dump Valve	372.20
Water Pump (Bell & Gossett)	281.55
C. Test Section/Support Structure	
Test Surfaces (5 sets of test plates--1 smooth, 3 with hemispherical roughness elements at different spacings and 1 with conical roughness elements. Manufactured by Hye Precision Products, Perry, Georgia)	33,500.00
Precision-ground support rails for test surfaces (Starrett)	1,218.80
D. Test Plate Power Supply/Heater System	
Motor-driven variable voltage transformers - 25 ea. (Superior Elec. Co. Model M-21)	6,000.00
Flexible silicone rubber coated plate heaters - 27 ea. (Watlow)	923.98
E. Transducers & Calibration Equipment	
Precision AC watt transducers - 2 ea. (Ohio Semitronics Model EW5-1B)	480.00
Differential Pressure Transducers (5 ea. - 2 for wind tunnel system, 3 for water tunnel system. Validyne Model P305D)	3,400.00
Thermistors - 65 ea. (Fenwall Model UUT-45J1)	234.82
Micromanometer (Meriam Model 34FB2TM)	2,742.00
Quartz Thermometer (Hewlett-Packard Model 2804A with 18111A Probe)	6,350.00

Constant Temperature Bath (Blue M Co. Model MR-3210A)	1,562.00
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F. Hot Wire Anemometry System

Two channel hot wire anemometer (TSI Model IFA100-2)	9,891.00
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Hot wire probes - 6 ea. boundary layer type and 6 ea. slant wire type (Dantec Models 55P05 and 55P03)	1,600.50
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Three custom probe holders/traverses for hot wires and thermocouple probe (Crafted by Mr. Robin Birch, Stanford, CA)	3,474.00
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Two Unislide traverses for Pitot probes (Velmx, Inc.)	412.45
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G. Data Acquisition and Control/Microcomputer System

Hewlett-Packard 3054S System consisting of the following:	47,357.00
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<u>Qty.</u>	<u>Item</u>
1	Basic 3054A System
6	Option 010 Multiplexer Assemblies
1	Option 020 Multiplexer Assembly
1	Option 030 High-speed Multiplexer Assembly
1	Option 050 Digital Interrupt Assembly
1	Option 060 Counter Assembly
1	Option 071 Bridge Completion Assembly
2	Option 110 Actuator Assemblies
1	Option 115 Actuator Assembly
2	Option 120 0-10V D/A Assemblies
1	Option 280 DVM and Current Source
2	Option 298 3498A Extenders
1	Option 456 56" Cabinet with fan

(The following items are the Series 200 microcomputer and related peripherals in the 3054S system).

1	9920S Model 220 Development System (Option 630)
1	Option 805 Large Keyboard
1	82913A 12-inch Monochrome Display
1	9133D 14.8 Mbyte Win. Disc with built-in 9122S
1	98620B Two channel DMA board

1	98640A Option 630 7-channel ADC interface
1	98644A RS-232C Serial Interface
2	98256A 256 Kbyte RAM boards
1	2225A 150 cps Thinkjet Printer
1	99261B Print Head Cartridges
1	92261N Ink-Jet fan-fold paper
1	7550A Plotter
1	07550-60210 Plotter Dustcover
1	09872-60066 Plotter Digitizing Sight
1	98820B Statistics Library (Part I)
1	10834A HP-IB to HP-IB Adapter
2	10833A 1 m HP-IB cables
1	10833D 0.5 m HP-IB cable
2	10833C 4 m HP-IB cable

H. Water Tunnel

Water Pump (Bell & Gossett Size 3E Series 1510) without motor.	\$ 1,405.00
Turbine Flow Meters (Hersey 1" SST Series and 3" SST Series)	1,710.50
Fluid Wafer Switch and accessories (Scanivalve Model W1266/2P-12T)	1,082.10

The other large expenditure was approximately \$10,400.00 paid for labor and materials to the Raspet Flight Research Laboratory at Mississippi State University. The craftsmen there fabricated the custom fiberglass pieces for both tunnels. These were the nozzle for the wind tunnel and the transition sections and test sections for the water tunnel.

In addition to the large items above, there were purchases of thousands of feet of electrical wiring, many electrical relays, switches and connectors, steel angle and tubing for support structures,

plywood and wood framing for portions of the wind tunnel; innumerable screws, bolts and other fasteners; and PVC piping and associated fittings.

III. Special Circumstances of Note

The primary change in the expenditure of funds from that in the original proposal was the deletion of some items of equipment and the use of the funds saved to pay for manufacturing the test plates.

The "savings" were:

(a) facility modifications cost \$5,200 rather than the budgeted \$9,450

(b) the three hot wire anemometry system linearizers (\$8,535) were omitted--this will be handled with software rather than hardware

(c) the oscilloscope (\$3,800) was omitted--an existing oscilloscope owned by the department will be used

(d) two precision watt transducers (\$480) were purchased rather than 26 (\$5,746)--a relay system will switch one transducer in and out of the plate power circuits and the second one is a backup.

These savings, added to the \$10,900 originally in the budget, almost totalled to the \$33,500 encumbered for the manufacture of five sets of test plates. These five sets are: one smooth set for baseline studies, three sets with hemispherical roughness elements at different spacings, and one set with conical roughness elements.

Considerable thought and time was spent on the design of the test plates. Dr. E. William Jones, the mechanical designer associated with this project, talked with literally dozens of potential manufacturers and investigated a wide range of methods for manufacturing the plates to the desired specifications. An acceptable set of specifications and price quotation was finally agreed upon with Hye Precision Products of Perry, Georgia. They proposed to develop a cold-forming process to produce the plates using aluminum and then finishing them with an electroless nickel coating.

The set of smooth plates (for baseline studies) has been delivered. Problems have been encountered in developing the manufacturing process so that the rough plates meet the required specifications. Work is continuing, and it is felt that a satisfactory solution will be achieved and the plates delivered. (This has not impacted the schedule of the research using the THTTA, since the debugging process on the facility and the initial sets of data use the set of smooth test plates.)

IV. Research Programs Using the THTTA and the Water Tunnel

THTTA

Research using the THTTA is currently funded for a 24-month period (May 1986-May 1988) under grant AFOSR-86-0178. This grant also includes \$10,000 for purchasing 2 additional sets of plates with

conical roughness elements. It is anticipated that an order will be placed with Hye Precision Products as soon as the manufacturing problems have been satisfactorily resolved.

Water Tunnel

The test surfaces (molded silicone rubber sheets) for use in the water tunnel test sections were to be provided by the Aeromechanics Division of the Flight Dynamics Laboratory. Skin friction data on twelve different surfaces were to be obtained under the experimental task of Contract F33615-84-K-3014, which had been extended through 15 May 1986. However, the subcontractor was slow in manufacturing and delivering the test surfaces (only 4 of the 12 were on hand by 15 May 1986) and the research funds which had remained in the contract were exhausted in the qualification and debugging efforts on the water tunnel systems.

Following telephone discussions with Mr. Mel Buck (AFWAL/FIMG), it has been proposed that Contract F33615-84-K-3014 be extended to 31 December 1987 and an additional \$37,309 in research funds be added to allow the objectives of the research program to be achieved.

END

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